Original Article

# Prevention of Atrioventricular Block During Radiofrequency Ablation by Pace Mapping of Koch's Triangle

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## Abstract

***Background:*** *Complete atrioventricular block (AV block) is a serious complication of slow pathway ablation therapy in the treatment of atrioventricular nodal re-entrant tachycardia (AVNRT). The present study was aimed at determining whether the electroanatomical pace mapping of Koch's triangle could significantly improve the safety, efficiency, and efficacy of selective slow pathway ablation in the treatment of AVNRT.*

***Methods:*** *A total number of 124 patients were selected to be studied consecutively for radiofrequency (RF) ablation therapy in the treatment of AVNRT. The subjects were divided into two groups: one, designated Group 1, to serve as the control group, and the other, designated Group 2, to serve as the study group. Conventional fluoroscopic slow pathway ablation was performed on the Group 1 subjects (n=66), with the Group 2 subjects receiving slow pathway ablation therapy guided by pace mapping of Koch's triangle. The slow pathway ablation in Group 2 (n=58) was performed with regard to the pace mapping data obtained on the basis of the St-H interval in the anteroseptal (AS), midseptal (MS), and posteroseptal (PS) regions of Koch's triangle. The anterograde fast pathway (AFP) location was determined based on the shortest St-H interval obtained by stimulating the anteroseptal (AS), midseptal (MS), and posteroseptal (PS) aspects of Koch's triangle.*

***Results:*** *In the Group 2 subjects, AFP location was AS in 50 (86.2%) of the cases, MS in 7 (12%) of the cases, and PS in 1 case (1.7%). One patient with posteroseptal AFP was administered retrograde fast pathway ablation therapy. One patient in the control group (Group 1), representing 1.5% of the group, developed persistent AV block in the course of the treatment, but none of the subjects in the study group (Group 2) developed any complications.*

***Conclusion:*** *It was concluded that an atypical fast pathway location is conducive to the development of atrioventricular block in the ablation therapy in AVNRT, with pace mapping of Koch's triangle having the capacity to eliminate the risk of any such complication developing. It follows that it helps to identify the AFP location before ablation therapy is administered in AVNRT, thereby improving the safety of the treatment.*

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## Introduction

Catheter ablation is an invasive procedure currently used in the treatment of atrioventricular nodal re-entrant tachycardia (AVNRT). Slow pathway catheter ablation in AVNRT has an extremely high success rate, about 100%,

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with only a 0.5% to 2% risk of causing second or third-degree atrioventricular (AV) block.[1-3] The risk of this complication arising is low, but, when it occurs, it may not be tolerated, especially by young patients, as it may lead to a life-threatening arrhythmia. The proximity of the location of the fast pathway to the compact atrioventricular node and the bundle of His can cause inadvertent AV block during slow pathway ablation in AVNRT. In other cases, the cause of the block could not be determined, as the energy is delivered to the posterior aspect of Koch's triangle, far from the usual site of the anterograde fast pathway and that of the AV node.[4] AV block generally occurs during RF delivery or within 24 hours after the procedure.

In this study, patients with atypical fast pathway location (in the midseptal [MS] or posteroseptal [PS] areas) were identified by pace mapping of Koch's triangle before ablation therapy administration. Ablation therapy was performed using the conventional slow pathway method in the control group (designated Group 1, n=66) and after pace mapping of Koch's triangle in the study group (designated Group 2, n=58). In this article, the occurrence of persistent AV block in the two groups during or after administering catheter ablation is examined and compared.

## Methods

Catheter ablation therapy was performed by two separate medical groups on 124 patients presenting with the typical form of AVNRT, referred to Modarres Hospital in Tehran, Iran, from September through February 2007. The diagnosis of typical AVNRT was based on a number of specific criteria including:

1- Initiation of the tachycardia after AH interval jump during atrial pacing

2- Earliest retrograde atrial activation in tachycardia at the bundle of His

3- HA interval in tachycardia less than the HA interval with ventricular pacing

4- Atrial and reciprocating tachycardia excluded

The 66 patients in Group 1 were administered the conventional slow pathway ablation therapy, while the 58 Group 2 patients received slow pathway ablation therapy with regard to the data obtained by pace mapping of Koch's triangle.

Routine laboratory tests, as well as transthoracic echocardiography and 12-lead ECG were performed for all the subjects. Any anti-arrhythmic medication was discontinued for at least five half lives before conducting the study. All the subjects arrived at the electrophysiology (EP) lab in a fasting state. Three quadripolar electrode catheters (with 5 mm inter-electrode distances) and one decapolar catheter were inserted in the high right atrium, the bundle of His region, the right ventricular apex, and the coronary sinus, in that order, via the right and left common femoral veins. The stimulation protocol involved atrial and ventricular pacing, and extra stimulation, which was performed on all the subjects. The specific location for RF energy delivery was identified, either through the conventional method or by pace mapping of Koch's triangle, and the radiofrequency (RF) energy was delivered accordingly. The temperature control was preset at 60° and the maximum power at 50 watts. For the 66 patients in Group 1, conventional slow pathway ablation was performed, with the 58 patients in the study group (Group 2) receiving ablation therapy under the guidance of pace mapping of Koch's triangle.

In Group 1, conventional slow pathway ablation was performed by positioning the catheter in the right anterior oblique view near the coronary sinus ostium. It was positioned in the zone of low frequency, fractionated, electrocardiogram recording (as described by Haissaguerre et al.) or potentially as described by Jackman et al. (sharp and late atrial electrocardiogram following a low amplitude atrial electrocardiogram during sinus rhythm).[2,3] If the application was unsuccessful, the catheter was repositioned progressively higher along the tricuspid annulus in an attempt to ablate the slow pathway (anatomical approach).

In Group 2, pace mapping of Koch's triangle data was obtained first, before the ablation therapy was administered. Pace mapping was performed by stimulating the site near the bundle of His, in the anteroseptal (AS) region of Koch's triangle, where the fast pathway is normally located, followed by the stimulation of the midseptal (MS) and posteroseptal (PS) aspects of Koch's triangle. A short St-H interval was normally recorded in the anterosuperior region of Koch's triangle, defined as the fast pathway region. The longest St-H interval, on the other hand, is defined as the slow pathway area. The ablation catheter was inserted into the AS region, where the highest His deflection was recorded, for stimulation. During the continuous pacing, the ablation catheter was withdrawn slowly until the atrium was captured (Figure 1). The 2-3 first captured beats were used for the St-H assessment, whereby the shortest St-H interval was selected. For the PS stimulation, the ablation catheter was inserted in front of the coronary sinus ostium. For the MS region stimulation, the area between the AS and PS aspects of Koch's triangle was stimulated. For locating the site of retrograde fast pathway, the right ventricle was paced; and the ventriculoatrial (VA) interval in the AS, MS, and PS areas was calculated. In cases where the fast pathway was found to be located in the AS region, slow pathway ablation was performed using the conventional approach. In patients with the fast pathway located in the MS region, radiofrequency ablation was performed strictly in the PS area. In cases where the anterograde (antegrade) fast pathway conduction was found to be in the PS region, retrograde fast pathway ablation was performed in the AS area. Persistent AV block was defined in cases where the block occurred during ablation and was found not to have cleared within 24 hours after the procedure was completed. The block was defined as transient second or third-degree in cases where the AV block occurred during ablation but cleared before the patient left the EP lab. The results of the ablation treatment of both groups are summarized in Table 1.

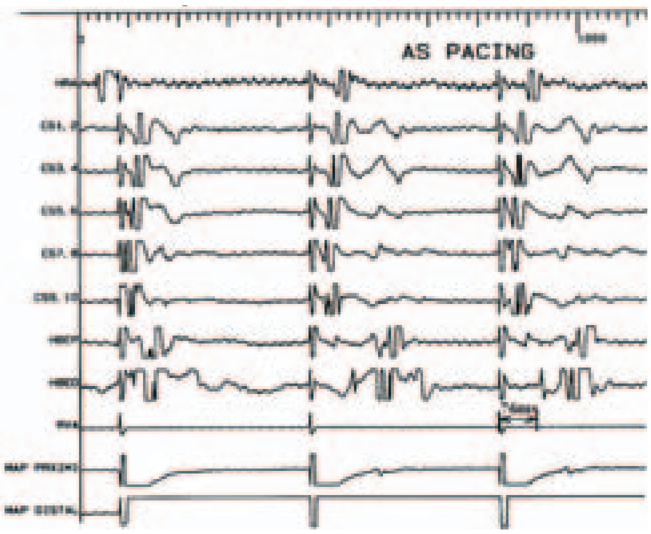
Table 1. The results of slow pathway ablation in conventional (group 1) and those patients who underwent pace mapping of Koch's triangle (group 2)

| Variable | Group 1 (n=66) | Group 2 (n=58) |
|---|---|---|
| Procedure time (min)* | 80.3±27.6 | 86.4±36.6 |
| Time RFA (sec)* | 186.6±165.9 | 228.8±222.1 |
| Transient block | 1(1.5%) | 0 |
| Permanent block | 1(1.5%) | 0 |
| Successful ablation | 100% | 98.3% |

*Data are presented as mean±SD

The results are expressed as mean values±standard deviation (SD) for the continuous variables. The results were analyzed via the chi-square test or Fischer's exact test, and the Mann-Whitney U Test was employed to compare the two groups. For statistical analysis, SPSS version 13 computer software was used. For all the tests, a P value of less than 0.05 ($P<0.05$) was considered statistically significant.

Figure 1. Pace mapping of A: anteroseptal (AS), B: midseptal (MS) and C: posteroseptal (PS) portion of Koch's triangle. Stimulation to His interval was performed at AS, MS and PS

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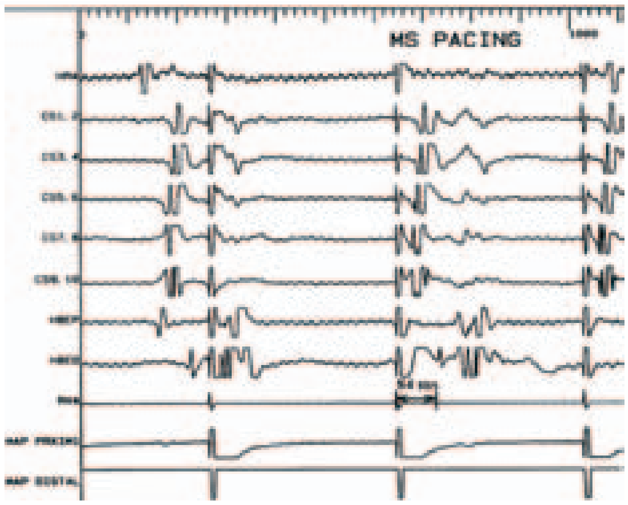


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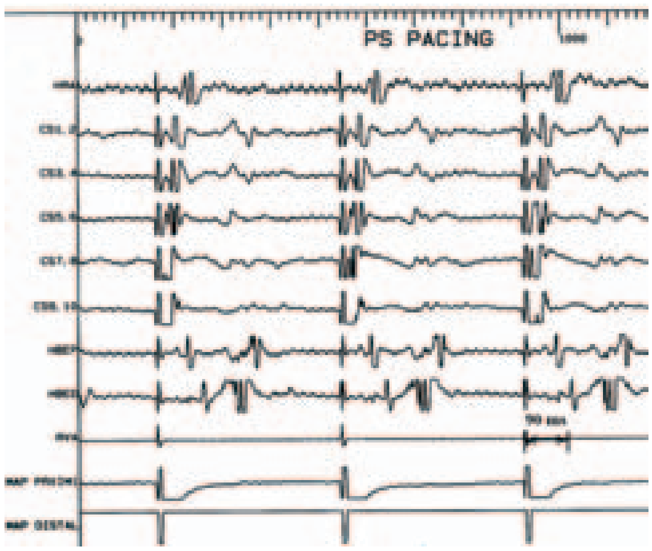


C

## *Results*

Group 1 consisted of 22 males and 44 females at an average age of 48±13.1 years, as compared with Group 2 comprised of 13 males and 45 females at an average age of 45.5±13.7 years.

In Group 2, AVNRT was induced in all the subjects (with or without Isoprel infusion). Among the 58 subjects in Group 2, the anterograde fast pathway location was in the AS region in 50 cases (designated Subgroup A), in the MS region in 7 cases (designated Subgroup B), and in the PS region in one case (designated Subgroup C). The results of Koch's triangle stimulation in Group 2 subjects are summarized in Tables 2-4.

Table 2. The results of pace mapping of Koch's triangle in three subgroups of patients*

| | Subgroup A (n=50) | Subgroup B (n=7) | Subgroup C (n=l) |
|---|---|---|---|
| Anteroseptal (ms) | 8 1.5±24.2 | 103.7±46.5 | 64 |
| Midseptal (ms) | 97.6±26.5 | 77.4±36.2 | 98 |
| Posteroseptal (ms) | 120.8±31.2 | 117.1±32.6 | 44 |

*Data are presented as mean±SD

Subgroup A, patients in whom anterograde fast pathway was in anteroseptal region of Koch's triangle; Subgroup B, patients in whom anterograde fast pathway was in midseptal region of Koch's triangle; Subgroup C, patients in whom anterograde fast pathway was in posteroseptal region of Koch's triangle

Table 3. Comparison of procedure and ablation times between subgroups of patients*

| Subgroup | No of cases | Procedure time (min) | Ablation time (sec) |
|---|---|---|---|
| A | 50 | 86.9 ±37.9 | 230.5 ±224.9 |
| B | 7 | 77.1± 23.6 | 142.9 ±49.6 |
| C | 1 | 120 | 746 |

*Data are presented as mean±SD

Subgroup A, patients in whom anterograde fast pathway was in anteroseptal region of Koch's triangle; Subgroup B, patients in whom anterograde fast pathway was in midseptal region of Koch's triangle; Subgroup C, patients in whom anterograde fast pathway was in posteroseptal region of Koch's triangle

Table 4. St-H interval in patients who underwent pace mapping of Koch' triangle*

| Region of Koch's triangle | Mean (msec) | Minimum (msec) | Maximum (msec) |
|---|---|---|---|
| Anteroseptal | 83.8±28.2 | 45 | 200 |
| Midseptal | 95.2±28.1 | 44 | 176 |
| Posteroseptal | 119.1±32.4 | 44 | 220 |

*Data are presented as mean±SD

Patients that presented with antegrade fast pathway (AFP) in the MS or PS regions were notified of the significant risk of atrioventricular block occurring in the course of the ablation therapy. One patient did not respond to slow pathway ablation despite having the AFP location in the AS region. It can be attributed to the slow pathway LA extension. In all the cases in Group 1, slow pathway ablation was successfully performed using the conventional method. Persistent first-degree AV block occurred in one (1.7%) of the Group 2 subjects with the AFP location in the PS area, whereby retrograde fast pathway ablation was administered in the AS region. Persistent AV block occurred in one (1.5%) of the Group 2 subjects, for whom a permanent pace maker was implanted. Transient second-degree AV block occurred in another patient in Group 1. The differences in persistent AV block did not represent a statistically significant difference between the groups. Similarly, differences in the mean procedure time, mean ablation time, and the gender and age differences were not statistically significant.

## Discussion

Slow pathway catheter ablation in the treatment of AVNRT carries the risk of causing complete atrioventricular block. It is most likely due to causing injury to the atrial inputs to the posterior aspect of the AV node, the bundle of His, or both the slow and the fast pathways, in the course of the treatment. It is not feasible to predict with certainty this complication arising in individual cases. The rate of the junctional rhythm during ablation has been shown to be a reliable indicator of impending AV block.[5] If the VA block occurs during the junctional rhythm, it is more applicative; it is a highly sensitive but not specific indicator. A study by Hintringer et al. showed only 23% of episodes of VA block during junctional rhythm to be associated with impaired antegrade conduction in a group of 58 patients. Although the occurrence of retrograde block with junctional rhythm has low specificity, it is not to be neglected, and the radiofrequency delivery is to be stopped at once when it occurs. Also, an interval of less than 20 milliseconds between the ablation atrial electrogram and the His atrial electrogram has been described as being predictive of AV block with RF. On the other hand, A/V ratio, presence of slow pathway potential, atrial electrogram fractionation, and the number of RF lesions were considered not to be predictive of AV block. Pietro Delise et al. showed the anterograde fast pathway to be abnormally located in the MS or PS region, or otherwise unable to conduct in an anterograde manner, in about 10% of patients with AVNRT.[1]

It has been postulated that atrioventricular node morphology is quite variable in humans.[6] It accounts for the possibility of AV block during slow pathway ablation. In a study by Denise et al., 909 consecutive patients were administered radiofrequency ablation for the treatment of AVNRT. The subjects were divided into two groups designated Group 1 (n=487) and Group 2 (n=422); Group 1 was assigned to undergo conventional slow pathway ablation, while Group 2 was assigned to undergo ablation therapy guided by pace mapping of Koch's triangle, which located the anterograde fast pathway interval, based on the shortest St-H interval. It was obtained by stimulating the anteroseptal, midseptal, and posteroseptal aspects of Koch's triangle. In Group 2 subjects, the AFP was anteroseptal in 384 (91%) of the cases, midseptal in 33 cases (7.8%), and posteroseptal or absent in 5 cases (1.2%). Of the 33 patients with midseptal AFP, slow pathway ablation was performed in 32 patients strictly in the posteroseptal area. Of the 5 patients with posteroseptal or absent AFP, on the other hand, retrograde fast pathway ablation was performed in 3 cases, with 2 patients declining treatment. Persistent second to third-degree AV block was induced in 7 (1.4%) of the cases in Group 1 versus none being induced in Group 2 (P=0.032).[4] In our study, slow pathway ablation in all the cases with midseptal and posteroseptal AFP location, 7 and 50 in number respectively, was performed in the PS region. The ablation procedure took longer in the Group 2 subjects than that in the Group 1 cases, but this difference in time was not statistically significant. In addition, in cases where the slow pathway was in the MS region (Subgroup B), the procedure time and the ablation time were less than those of the Subgroup A cases. It suggests that when the slow pathway is near the fast pathway (as in Subgroup B), it is more sensitive to RF energy than when it is further away from it (as in Subgroup A).

Transient AV block was detected in one of the patients in Group 1 versus none in Group 2. Permanent (third-degree) AV block occurred in one patient in Group 1, again with no cases found in Group 2. Persistent first-degree AV block occurred in one patient in Group 2 after retrograde fast pathway ablation, but the block did not show any progression in the first 4-week follow-up.

This study has weaknesses on several grounds rendering it to some extent inconclusive. They include its having been conducted in a single-blind non-randomized manner. Furthermore, the small number of subjects (especially in Subgroup C) does not allow drawing firm conclusions regarding the efficacy of pace mapping of Koch's triangle in averting AV block in all patients with AVNRT on the basis of the results obtained.

## Conclusion

The present study concluded that an atypical location of fast pathway is conducive to complete AV block occurring as a result of catheter ablation in the treatment of AVNRT. Pace mapping of Koch's triangle can reveal any such abnormalities and may be useful in guiding ablation, thereby avoiding AV block. It greatly improves the safety of radiofrequency ablation therapy in AVNRT through identifying the exact location of anterograde fast pathway, thus guiding the ablation therapy. It can greatly diminish the likelihood of AV block occurring in the course of the treatment. It is, however, worthy of note that the total number of the subjects studied being small, it is mandatory that further trials be made to allow a more definitive conclusion to be reached.

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